AIR FORCE

QUALIFICATION TRAINING PACKAGE (AFQTP)

for

ELECTRICAL SYSTEMS

(3E0X1)

MODULE 12

PLANNING AND LAYING OUT WORK

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MODULE 12
PLANNING AND LAYING OUT WORK

Career Field Education and Training Plan (CFETP) references from 1 Apr 97 version.

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AIR FORCE QUALIFICATION TRAINING PACKAGES (AFQTPs)
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ELECTRICAL SYSTEMS
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INTRODUCTION

Before starting this AFQTP, refer to and read the "Trainee/Trainer Guide" located on the AFCESA Web site **http://www.afcesa.af.mil/.** This guide will be found at each AFS's AFQTP download page.

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.

MANDATORY minimum upgrade requirements:

Core task:
AFQTP completion
Hands-on certification

Diamond task:
AFQTP completion
CerTest completion (80% minimum to pass)

Note: *Trainees will receive hands-on certification training when equipment becomes available either at home station or at a TDY location.*

Put this package to use. Subject matter experts under the direction and guidance of HQ AFCESA/CEOT revised this AFQTP. If you have any recommendations for improving this document, please contact the Electrical Career Field Manager at the address below.

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PLANNING AND LAYING OUT WORK

MODULE 12 **AFQTP UNIT 1**

READ WIRING DIAGRAMS, SCHEMATICS, SPECIFICATIONS, DRAWINGS, STAKING SHEETS, AND ONE LINE DIAGRAMS (12.1.)

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READ WIRING DIAGRAMS, SCHEMATICS, SPECIFICATIONS, DRAWINGS, STAKING SHEETS, AND ONE LINE DIAGRAMS

Task Training Guide

STS Reference Number/Title:	12.1. – Planning and laying out work, read wiring diagrams, schematics, specifications, drawings, and one line diagram
Training References:	• CDC 3E051A, Vol. 4 • CDC 3E051B, Vol. 3
Prerequisites:	• Possess as a minimum a 3E031 AFSC.
Equipment/Tools Required:	• Wiring diagram, schematic, specifications, drawings (blueprints), and staking sheet
Learning Objective:	• Given blueprint set and diagrams, read wiring diagrams, schematics, specifications, drawings, staking sheets, and one line diagram.
Samples of Behavior:	• Following approved methods, read wiring diagrams, schematics, specifications, drawings, staking sheets, and one line diagrams.

READ WIRING DIAGRAMS, SCHEMATICS, SPECIFICATIONS, DRAWINGS, STAKING SHEETS, AND ONE LINE DIAGRAMS

Background: The first thing you will need before attempting to install any circuit is something that tells you exactly the type, size and location of the circuit. This information is usually contained in a blueprint or drawing of some kind. Therefore, it is necessary that you are able to read and interpret drawings and blueprints.

People have used pictures to convey their thoughts for centuries. It would be difficult for an engineer or architect to describe the exact length, width, or height of a building or what the finished product will look like without a drawing of some type. A word description of a building would be very long and hard to read and could lead to disastrous results. The set of plans drawn by an architect or engineer, containing all of the information and dimensions necessary to carry a job through to completion, are called working drawings. Reproductions of these drawings are called a set of blueprints. Like other workers in the building trades, you need blueprints and drawings to tell you where a circuit is to be located, what size it will be, and to provide other details about the electrical installation.

Drawings are a set of instructions on how to construct a building or some other structure. They are also known as "blueprints". The term "blueprint" originally came from a printing process that used blue paper with white lines and symbols. This process has since been reversed, and now you get white paper with blue, black, or brown lines. Blueprints show, with lines and symbols, the shape and size (by reduction to scale) of a structure, materials required, location of fixtures and outlets and how it all fits together. Drawings included in a normal set of blueprints are plot plans, exterior elevation, interior elevation, floor plans, wiring plans and sectional.

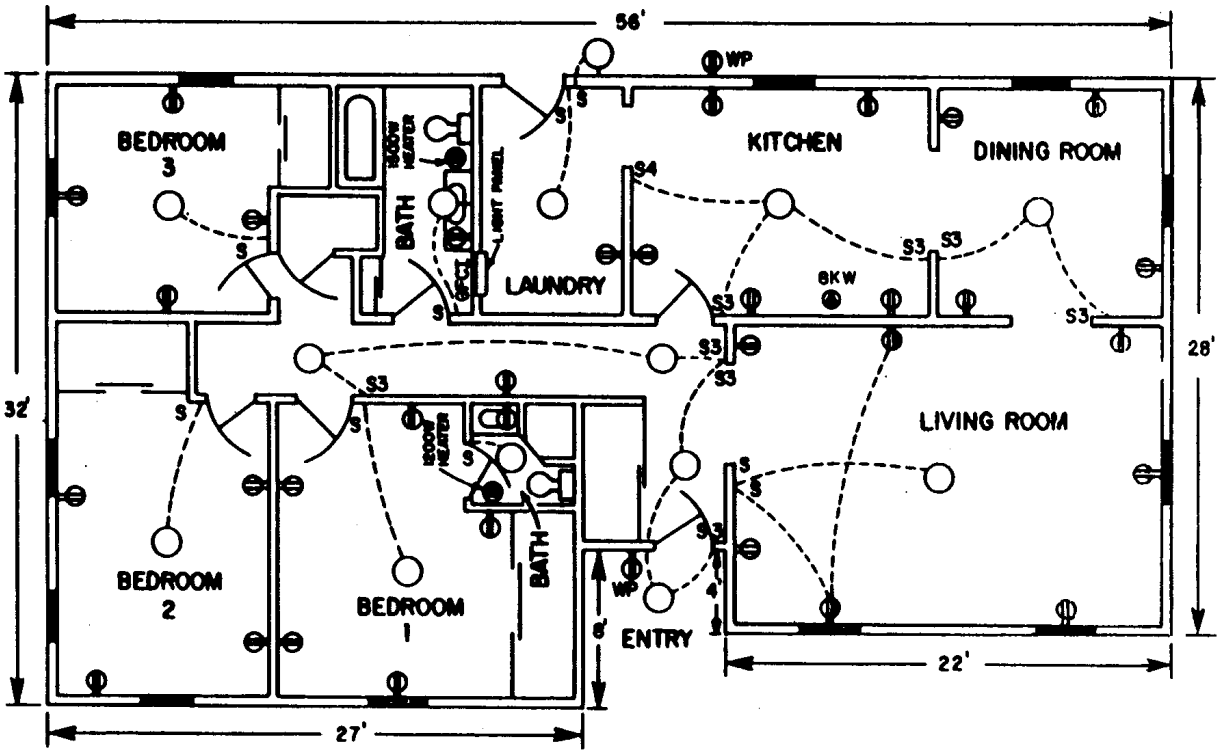
- The **plot plan** is the starting point for any building that is to be constructed. It shows where the building is to be placed on the plot of land or property and shows the shape and dimensions of the plot. When streets or drives bound the plot plan, such information is shown also. This plan aids the electricians by showing the point where the service drop from the pole is to be connected or what route the cable needs to be run for an underground service.

- The **exterior elevation** drawings show horizontal views of the finished exterior sides of the buildings. They show exterior trim, finish, window and door openings, roofing, and brickwork. In addition, finished gradelines and floorlines are shown. This information is helpful in locating outside lights and receptacles (outlets).

- The **interior elevation drawings** show horizontal views of inside wall space that contain counters, sinks, cupboards, and other special features. These drawings will help in determining how high and what distances to place receptacles (outlets) and switches in kitchens and bathrooms.

- The **floor plan** shows exactly what the name implies, a plan of the floor from a vertical viewpoint. The drawing includes the layout of all interior and exterior walls, including windows and doors. In addition, it shows the heating, electrical and plumbing fixtures. Although, floor plans for small buildings may show most wiring requirements; detailed

wiring requirements will be shown on a wiring plan for houses and large buildings. A typical floor plan is shown in Figure 1.



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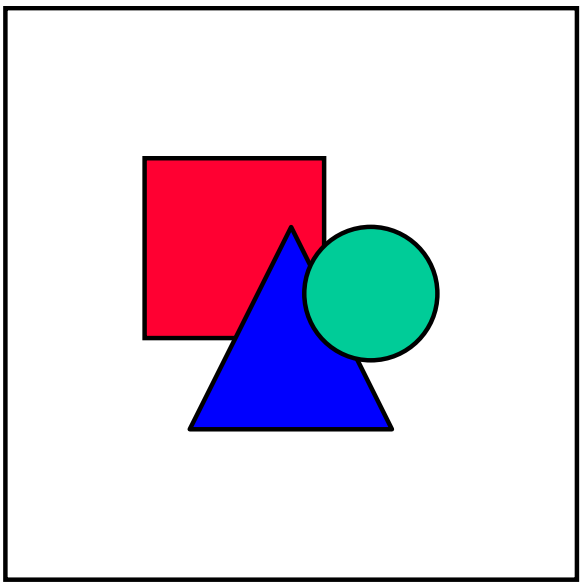

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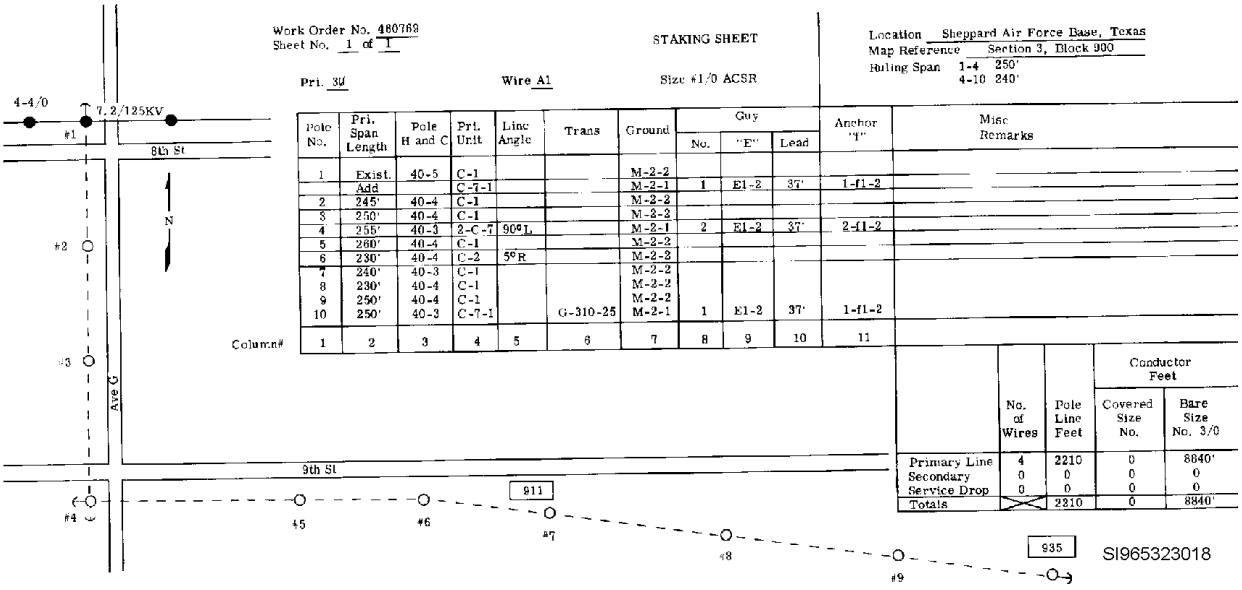
Figure 1, Typical Floor Plan

- **Wiring Plans** are drawings that show electrical wiring in schematic form. Rather than overabundant and confusing details of actual wiring; symbols, notes and specifications give all the information needed for installation. Knowing or referencing symbols is the only way you will be able to follow, interpret and understand wiring plans. One example would be to know that a dot on two or more intersecting lines means the lines are connected, if no dots are present then the lines may cross but are not connected together. Another would be to know that a "Home Run" are the wires that connect from the first fixture to the panel box. If available, wiring plans will be the primary source for installation and troubleshooting information.

- **Sectional** or **detail drawings** are often added to others to show a specific detail that is to small or complex to show in other views. These are large scale drawings which clearly show the parts of a structure that can't be shown accurately in the elevation views or floor plan. Since it's not always possible to place all details on the main drawing to which they apply, detail drawings are put on sheets that contain nothing but details. A reference will be on the main drawing (elevations or floor plans) referring to the appropriate detail sheet. These drawings may be a cross-sectional view of the building supports, show story and ceiling height or show what the floors are made of. Hardware needed to mount conduit, wiring and boxes to wooden joists is different than for some other types of construction. In addition, they will show thickness of wall covering which will affect the depth you mount your electrical boxes. Many of these things might influence the method of doing electrical work and the kind of material that is to be used.

A **staking sheet** is a drawing of a distribution line showing pole locations and line's relationship to the rest of the distribution system. It's useful for construction and maintenance on a specific line, and it's used to keep the system up to date. The staking sheet shows the location of each pole, how it is to be installed and the amount of material required for installation. It provides information on pole identification, specifications, and other material (Figure 5).



Pole No.	Pri. Span Length	Pole H and C	Pri. Unit	Line Angle	Trans	Ground	Guy No.	Guy "E"	Guy Lead	Anchor "I"	Misc Remarks
1	Exist.	40-5	C-1			M-2-2					
	Add		C-7-1			M-2-1	1	E1-2	37'	1-f1-2	
2	245'	40-4	C-1			M-2-2					
3	250'	40-4	C-1			M-2-2					
4	255'	40-3	2-C-7	90°L		M-2-1	2	E1-2	37'	2-f1-2	
5	260'	40-4	C-1			M-2-2					
6	230'	40-4	C-2	5°R		M-2-2					
7	240'	40-3	C-1			M-2-2					
8	230'	40-4	C-1			M-2-2					
9	250'	40-4	C-1			M-2-2					
10	250'	40-3	C-7-1		G-310-25	M-2-1	1	E1-2	37'	1-f1-2	
Column#	1	2	3	4	5	6	7	8	9	10	11

	No. of Wires	Pole Line Feet	Conductor Feet: Covered Size No.	Conductor Feet: Bare Size No. 3/0
Primary Line	4	2210	0	8640'
Secondary	0	0	0	0
Service Drop	0	0	0	0
Totals		2210	0	8640'

Figure 5, Sample Staking Sheet

To be able to read these drawings, you must know what the lines, scales, and symbols mean and how to apply them. Included with the blueprints are scales, legends, notes and specifications.

All of the drawings mentioned so far are proportional reductions of the final structure. The amount of reduction depends on the size drawing desired. Dimensions in feet are reduced to parts of an inch. For example, 1 foot may be reduced to one-fourth or one-eighth of an inch. The reduction is called the scale of the drawing. If the scale of a drawing is $1/4$ inch = 1, a 1-inch line would represent 4 feet on the actual structure.

The location of outlets, switches, fixtures, etc., is shown on a floor plan by means of pictures that represent the actual device. These pictures are called symbols and are standardized for ease of understanding by those who make the drawings and those who read the drawings. A set of standardized symbols, put out by the American National Standards Institute (ANSI), is used for electrical blueprints and drawings. A few of the more common symbols you will see and use are shown in Figures 2 and 3. Legends used with floor plans or other drawings are a clarification of the symbols used on that particular drawing. (See Figure 1, lower right-hand corner). The legend helps workers, who may not be familiar with electrical symbols, install outlets and switches in the proper locations. It can help the electrician if standardized symbols are not used.

Many times information must be provided as to a certain bolt to use in a particular spot or which size and type of doors are placed at each location. Notes accomplish this. They may be general or specific and add extra information that may apply to the entire drawing or a specific part. Specific notes identify features such as size of conduit, kind of connectors, etc. and has an arrow pointing to the part of the drawing it concerns. General notes are grouped in the lower right hand corner of the drawing and gives general information about general materials such as doors, windows, etc.

Specifications are also a vital part of a set of drawings. They clarify information shown on the drawings. They are written instructions, usually in a separate booklet, that pertain to the

materials that will be used to complete the job. Specifications may require exact types and kinds of materials, dimensions, colors, quality, finishes, and other details to be used. "Specs" also give a running account of the installation of the electrical equipment on a job. This enables you to go ahead with the job even though a similar job has never been done.

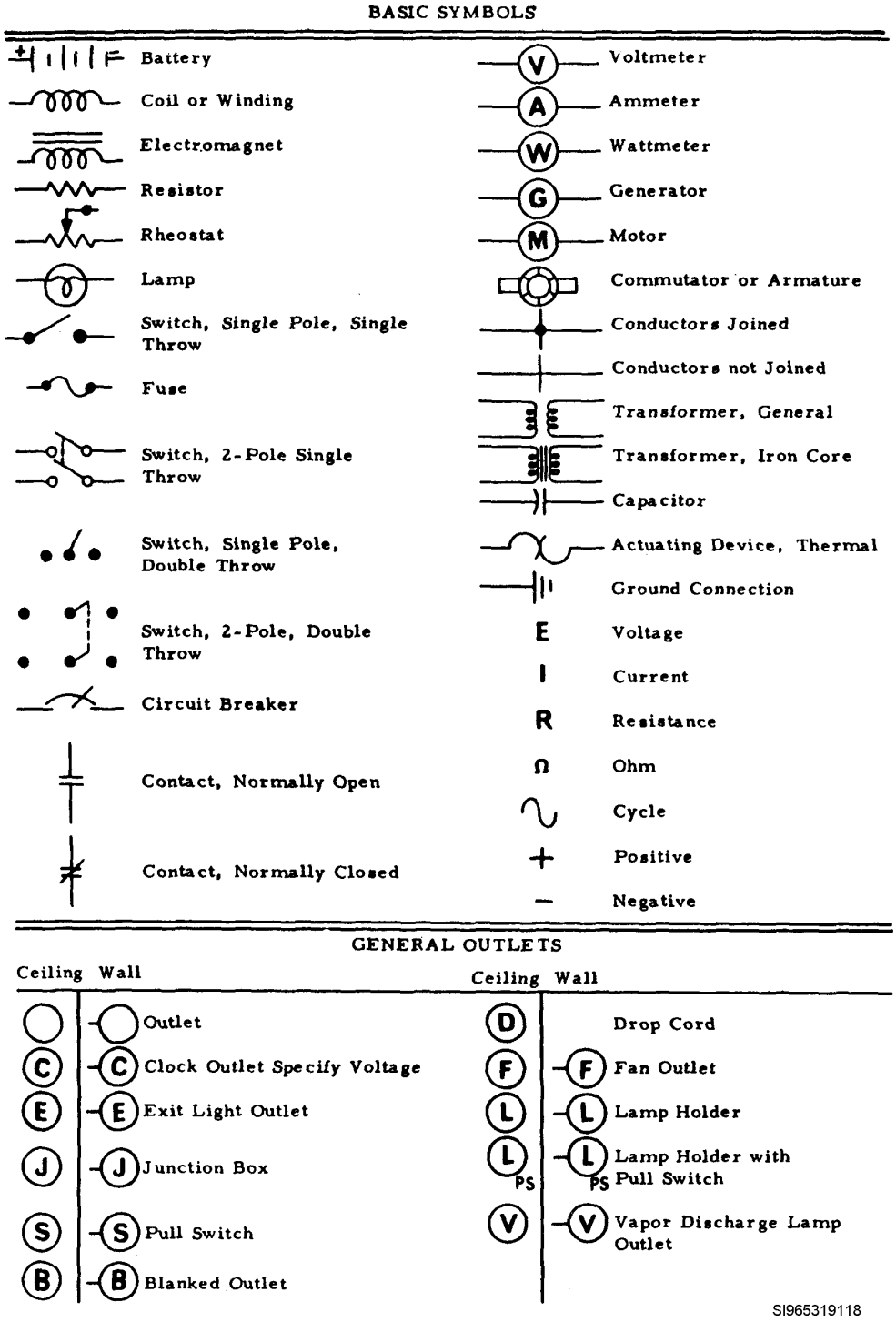


Figure 2, Symbols

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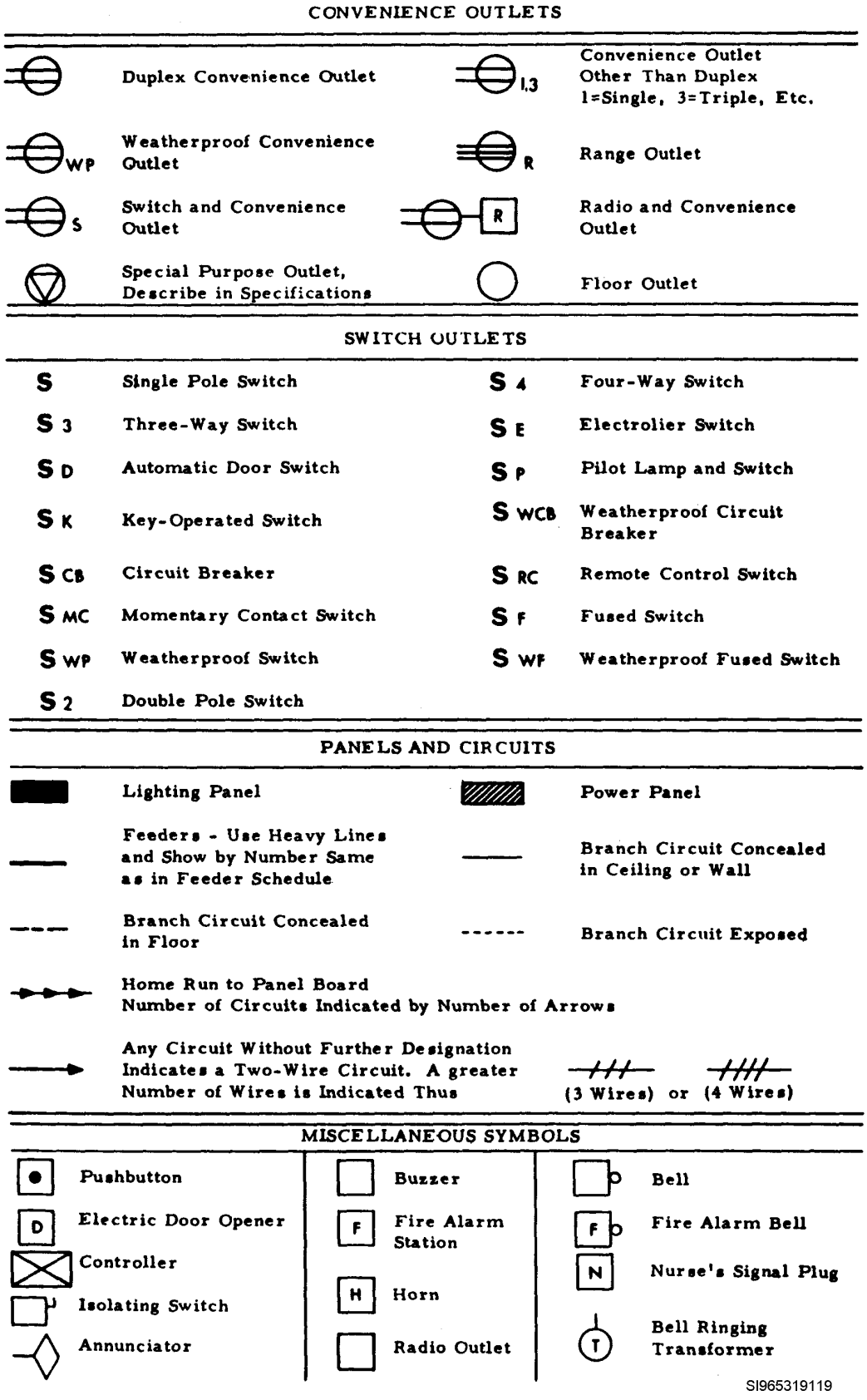

Figure 3, Symbols

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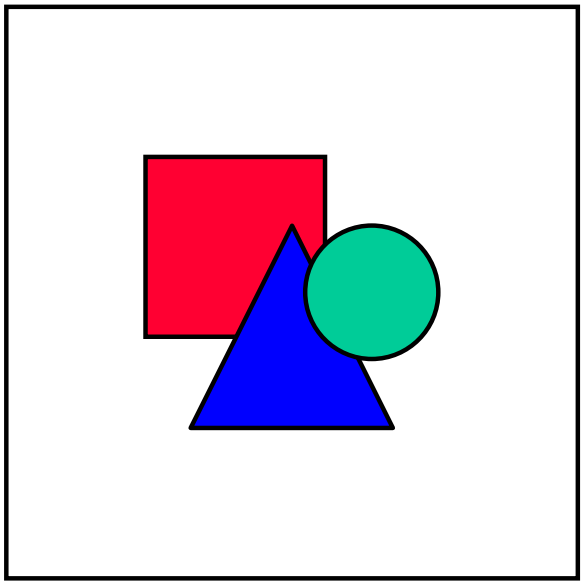
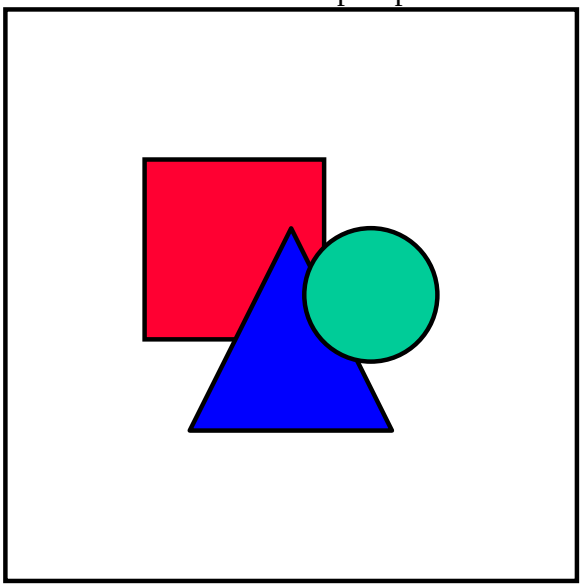


In addition to blueprints, you will be working with drawings called electrical diagrams. A diagram is defined as a line drawing that shows arrangement or relationship of parts. Electrical diagrams are usually used to show how parts of a piece of equipment or several pieces of equipment are wired together. There are basically four types of electrical diagrams (block, wiring, connection, and schematic). These diagrams are similar to each other and their names are sometimes used interchangeably, but they do have differences.

A **block diagram** is a simple drawing showing the relationship of major parts of a system. Figure 4, far left, shows a block diagram of a motor control system. You can easily see why it is called a block diagram. The parts or components in any block diagram are just as they appear in this drawing, as blocks. A line or lines that show the relationship of the parts connect them. Block diagrams are used often to explain power distribution systems. The internal connections of the components are not shown in these drawings. The blocks are simply labeled to show what each represents. These drawings would be of little help for troubleshooting.

The **wiring diagram**, which is like a picture drawing, shows the wiring between components and the relative position of the components. The second diagram from the left in Figure 4 shows a wiring diagram of the same motor control system shown by the block diagram. You can see that instead of blocks used to show components, a picture of the component is used. You also can see that the lines used to show the wiring are marked numerically or alphanumerically. Lines L1, L2, and L3 are incoming power leads and the diagram shows which terminals they are connected to in the starter. Wiring diagrams are used often with a list of repair parts and can be used to do some troubleshooting.



The third diagram shown in Figure 4 is a **connection diagram**. It makes use of diagram symbols instead of pictures to show components. It also shows all the internal and external circuit connections, and these can be read and traced more easily than on the wiring diagram. In the connection diagram, the components are still shown in their relative positions. This diagram can help you connect all the wiring and trace any part of the circuit,

which makes it a very valuable troubleshooting tool. It is often found inside the cover of a piece of equipment.

The **schematic diagram** is a drawing that shows the electrical plan of operation of a piece of equipment or component. The relative position of parts is not shown in this type of diagram. The schematic diagram, like the connection diagram, makes use of symbols instead of pictures. The schematic in Figure 4 shows the same motor control system just like the other three diagrams. It is laid out so that the components are in line to make it easy to trace the operation. The schematic is sometimes called an elementary or one-line diagram and is very useful in troubleshooting or tracing the plan of electrical operation.

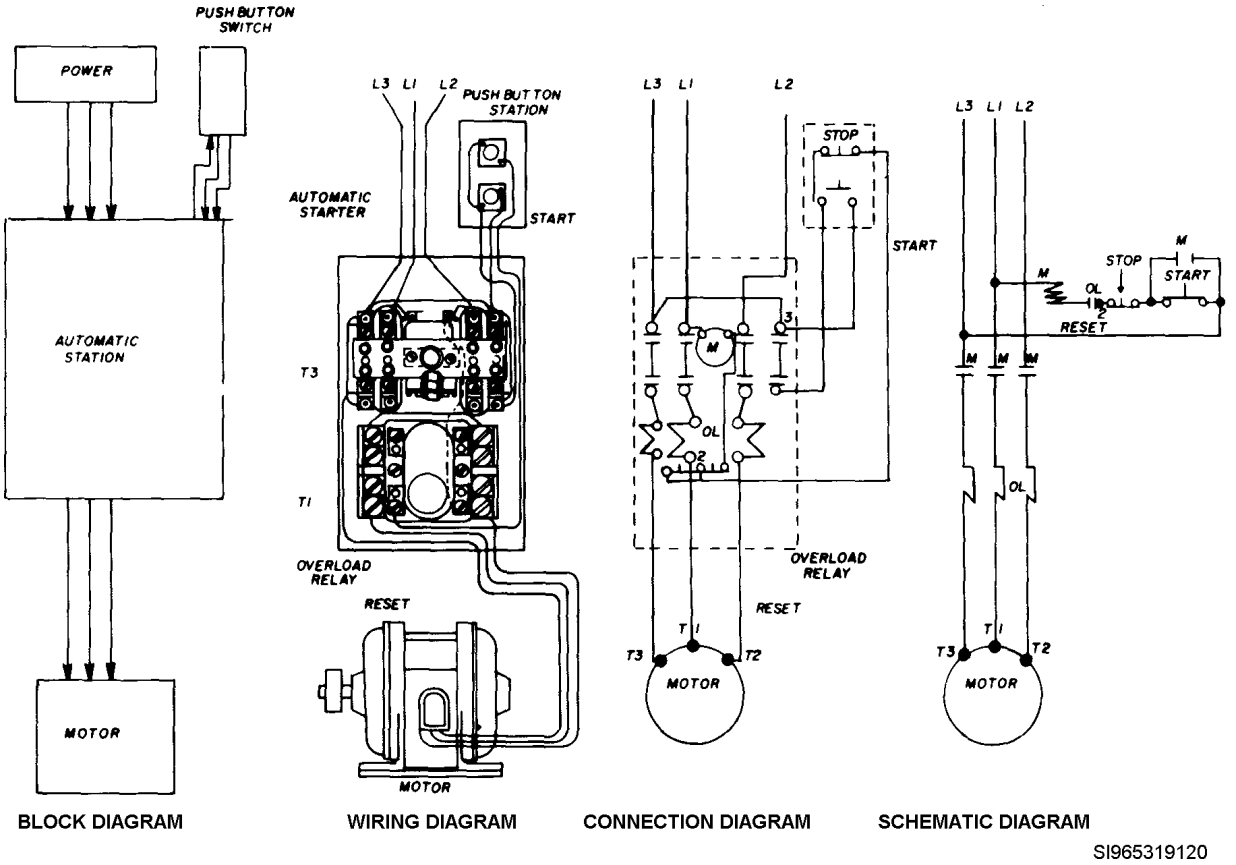


Figure 4, Electrical Diagrams

To perform the task, follow these steps:

Step 1: Pick a facility on your base and obtain the blueprints for it.

> **NOTE:**
> Most drawings can be found in the Site Development or Maintenance Engineering elements of your squadron or your section may even keep diagrams in the shop. Some wiring diagrams also come with equipment you are installing

- **Read the plot plan diagram. Read the scale.**

- Need to be able to convert from fractions of inches to feet to figure out distances such as heights, widths, and lengths.
- Review the legend and examine the symbols used on the drawing. These symbols will be used throughout the blueprints to determine your size, type and location of circuits and fixtures.
- Review the notes look for any special information that affects the type of electrical material or installation of the materials.
- Review specifications and examine specific types of materials and equipment required.
- Read the sectional drawing and examine for more detailed instructions on special material or equipment and installation procedures.
- Identify how and where power is routed.
- Identify type and size of electrical service.
- Identify connection point to the facility.
- Identify location of electrical fixtures (area lighting, etc.) not attached to facility.
- Identify what material is needed.

- **Read the exterior elevation drawing.**
  - Need to be able to convert from fractions of inches to feet to figure out distances such as heights, widths, and lengths.
  - Review the legend and examine the symbols used on the drawing. These symbols will be used throughout the blueprints to determine your size, type and location of circuits and fixtures.
  - Review the notes look for any special information that affects the type of electrical material or installation of the materials.
  - Review specifications and examine specific types of materials and equipment required.
  - Read the sectional drawing and examine for more detailed instructions on special material or equipment and installation procedures.
  - Identify what fixtures are attached to the outside of the facility
  - Identify how and where power is routed.
  - Identify type and size of power required.
  - Identify location of fixtures.
  - Identify what material is needed.

- **Read the interior elevation drawing.**
  - Need to be able to convert from fractions of inches to feet to figure out distances such as heights, widths, and lengths.
  - Review the legend and examine the symbols used on the drawing. These symbols will be used throughout the blueprints to determine your size, type and location of circuits and fixtures.
  - Review the notes look for any special information that affects the type of electrical material or installation of the materials.
  - Review specifications and examine specific types of materials and equipment required.

- Read the sectional drawing and examine for more detailed instructions on special material or equipment and installation procedures.
- Identify what fixtures are attached to elevated areas inside the facility.
- Identify how and where power is routed.
- Identify type and size of power required.
- Identify location of fixtures.
- Identify what material is needed.

- **Read the floor plan.**
  - Need to be able to convert from fractions of inches to feet to figure out distances such as heights, widths, and lengths.
  - Review the legend and examine the symbols used on the drawing. These symbols will be used throughout the blueprints to determine your size, type and location of circuits and fixtures.
  - Review the notes look for any special information that affects the type of electrical material or installation of the materials.
  - Review specifications and examine specific types of materials and equipment required.
  - Read the sectional drawing and examine for more detailed instructions on special material or equipment and installation procedures.
  - Identify type and size of power required.
  - Identify location of fixtures.
  - Identify how and where power is routed.
  - Identify location of fixtures.
  - Identify what material is needed.

Step 2: Obtain a staking sheet.

- **Review the legend**
  - Examine the legend for symbols used on the drawing. These symbols will be used throughout the blueprints to determine your size, type and location of circuits and fixtures.
- **Read the construction drawings.**
  - Examine the specifications for more detailed instructions on special material or equipment and installation procedures.
- **Read the staking sheet**
  - Identify what is being constructed.
  - Identify lengths of span.
  - Identify types of equipment being installed.
  - Identify size and types of material required.
  - Identify types and location of supports.

Step 3: Obtain wiring diagrams and schematics.

- **Read the schematic.**
  - Trace circuit flow from power source, through the devices and into end equipment.
  - Identify parts in circuit for troubleshooting connections and devices.
- **Read the wiring diagram.**
  - Trace circuit flow from power source, through the devices and into end equipment.
  - Identify parts in circuit for installation connections.

Review Questions
for
Read Wiring Diagrams, Schematics, Specifications, Drawings, Staking Sheets, and One Line Diagrams

Question	Answer
1. The exterior elevation drawings show views of the finished interior side of the buildings.	a. True b. False
2. What is a detail drawing used for?	a. Show views of inside wall space that contain special features. b. Show a cross-sectional view of the building supports or foundation c. Shows layout of all interior and exterior walls. d. All of the above
3. If the drawing scale is 1/4 in.=1 ft., then how far would a line 2 inches long actually represent?	a. 8 ft b. 2 ft c. 1 ft d. 1/2 ft
4. What kind of information can be found in the legend?	a. Location of fixtures. b. History of the project. c. Clarification of symbols. d. Types and kinds of material.
5. The four basic electrical diagrams are block, wiring, connections, and staking.	a. True b. False
6. On the staking sheet (Figure 5), what information does column four contain?	a. Pole number b. Type of pole c. Line angle d. Type of construction.
7. What do lines L1, L2, and L3 designate in diagrams?	a. Motor connections b. Start/stop connections c. Incoming power leads d. Outgoing power leads

READ WIRING DIAGRAMS, SCHEMATICS, SPECIFICATIONS, DRAWINGS, STAKING SHEETS, AND ONE LINE DIAGRAMS

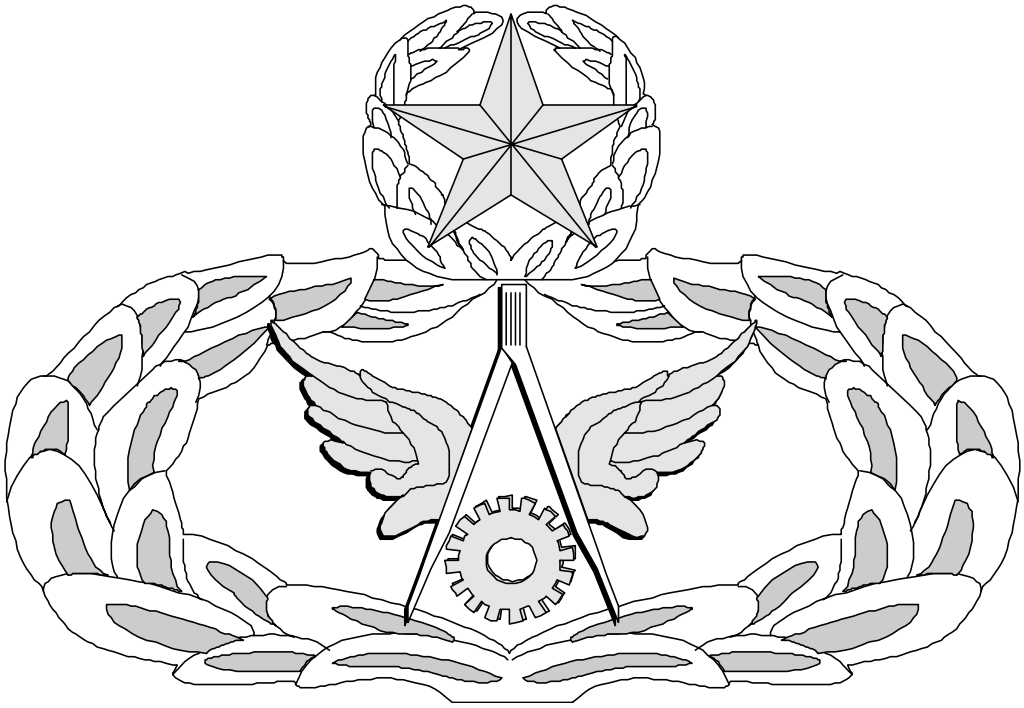
Performance Checklist		
Step	**Yes**	**No**
1. Did the trainee interpret the scale?		
2. Did the trainee interpret the blueprint legend?		
3. Did the trainee properly read the notes?		
4. Did the trainee properly read the sectional drawing?		
5. Did the trainee properly read the specification drawing?		
6. Did the trainee properly read the plot plan?		
7. Did the trainee properly read the exterior elevation drawing?		
8. Did the trainee properly read the interior elevation drawing?		
9. Did the trainee properly read the floor plan drawing?		
10. Did the trainee interpret the staking sheet legend?		
11. Did the trainee properly read the construction drawing?		
12. Did the trainee properly read the staking sheet?		
13. Did the trainee properly read the schematic diagram?		
14. Did the trainee properly read the wiring diagram drawing?		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

Air Force Civil Engineer

QUALIFICATION TRAINING PACKAGE (QTP)

REVIEW ANSWER KEY



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ELECTRICAL SYSTEMS

(3E0X1)

MODULE 12

PLANNING AND LAYING OUT WORK

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READ WIRING DIAGRAMS, SCHEMATICS, SPECIFICATIONS, DRAWINGS, STAKING SHEETS, AND ONE LINE DIAGRAMS

(3E0X1-12.1.)

Question	Answer
1. The exterior elevation drawings show views of the finished interior side of the buildings.	b. False
2. What is a detail drawing used for?	b. Show a cross-sectional view of the building supports or foundation.
3. If the drawing scale is 1/4 in.=1 ft., then how far would a line 2 inches long actually represent?	a. 8 feet
4. What kind of information can be found in the legend?	c. Clarification of symbols.
5. The four basic electrical diagrams are block, wiring, connections, and staking.	b. False
6. On the staking sheet (Figure 5), what information does column four contain?	d. Type of construction.
7. What do lines L1, L2, and L3 designate in diagrams?	c. Incoming power leads